ORIGINAL ARTICLE

Mathematics teacher professional development in and through internet use: reflections on an ethnographic study

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Abstract This paper is a reflection on a model for mathematics teacher professional development with respect to technology. The model was informed by three interrelated concepts: (1) a theory of teacher professional development from analysis of the field, (2) the zone theory of teacher professional learning, and (3) ethnography as a method. The model was applied in a study that focused on the uses of the Internet for primary mathematics teacher professional development, particularly to exploit the potential of the Internet for professional learning and to use it in professional work. This is illustrated through selected critical events over an eight-month ethnographic intervention in a primary mathematics classroom in Australia. Though the model is theoretically grounded, it opens up questions about the power, potential, and challenges as well as its feasibility, with respect to not only the teacher but also the ethnographer.

Keywords Professional development · Ethnography · Zone theory of professional learning · Intervention · Internet

Background

The Internet has great potential for mathematics teacher professional development. It provides a wide range of mathematical learning resources (e.g., Cavanagh and Mitchelmore 2011; Moore and Chae 2007; Moyer et al. 2008); it opens opportunity to build up learning communities among the Internet users (e.g., Hsu 2004; Lock 2006; Sarah 2010); and it enables mathematics teachers to collaborate at local, regional, national, and global levels (e.g. Dalgarno and Colgan 2007; Spicer and Dede 2006). However, there are two major issues regarding the Internet and teacher professional development evident in the literature.

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First, it seems clear that professional development via the Internet has had positive effects on teachers' beliefs about the beneficial role of the technology as a learning and teaching tool (Gibson and Skaalid 2004), and has increased teacher self-efficacy (Watson 2006) and positive attitudes to their profession (Hsu 2004). It has also helped teachers to become more reflective (Hsu 2004), to gain benefits from interactions with other teachers through online professional development (Newell et al. 2002) and to experience "fun" and "exciting" learning using the Web (Moor and Zazkis 2000). However, these studies did not elaborate whether the teachers used the new knowledge and skills in their teaching practices, that is, whether these programs had influenced their daily classroom instruction. In fact, research is now making clear the complexity of teaching with the Internet (e.g., Cavanagh and Mitchelmore 2011; Wallace 2004).

Second, with such ready access to substantial professional resources, teachers should be able to readily engage in self-directed professional development. However, expecting teachers to optimise the potential of the Internet is not a simple task. Certain features of the Internet can be problematic (see e.g., Cuban et al. 2001; Kafai et al. 2007). The Internet provides not only reliable information, but also non-reliable information; and not only up-to-date information, but also out-of-date information. Added to this is its instability, as information that is available now can be unavailable at any time in the future. The problem for teachers is to know which information found on the Internet is reliable and appropriate to the curriculum (Cuban et al. 2001), and to understand the use of the Internet for professional learning and for fostering constructive mathematics teaching (Kaput 1989, 1992). In fact, two large-scale studies reported that the potential of the Internet for teacher professional development has not been optimised (Becker 1999; Gibson and Oberg 2004).

These two issues, complexity and limited use, suggested a need to investigate how mathematics teachers could use the Internet for their learning: to promote their knowledge, develop their understanding of new instructional practices, support their on-going learning process, or use the Internet in professional work (such as incorporating the Internet into mathematics teaching and learning). To pursue such a study further required an examination of the characteristics of effective professional development—a review that is discussed below. The focus of the review was to identify inadequacies in existing professional development programs (e.g., Borko 2004; Little 1993; Wilson and Berne 1999) as well as the potential advantages and limitations of using the Internet for professional development. As evidenced below, this review suggested a need to develop and explore a model that sheds light on how the Internet might be used to support primary mathematics teacher professional development. This issue was addressed through the medium of an ethnographic study in an Australian primary school.

The purpose of this paper is to reflect on the model (i.e., a model that incorporates five characteristics of effective professional development and zone theory frameworks within an ethnographic research design (Patahuddin 2012)) that was applied in this study by focusing on one case. To begin, a theoretical framework for the study is presented, followed by a description of the research method and the story of the ethnographic intervention through selected events, focusing on two critical issues. First, an intervention needs to start where the teacher can connect and, second, intervening agents are required to be critically vigilant with respect to the relationship between the researcher and the teacher. The analysis of selected critical events involving both issues using the framework developed in turn enables reflection back on the model with respect to its power, challenges, promise, and feasibility, not only for the teacher, but also for the ethnographer.

Theoretical underpinnings

Effective teacher professional development and ethnography

An analysis of existing literature (e.g., Abdal-Haqq 1996; Goos et al. 2007a; Little 1993; Putnam and Borko 1997) suggests that there are five characteristics that are most suited for teacher professional development using the Internet. These characteristics include: (1) ongoing professional development; (2) collaboration; (3) student-orientated focus; (4) contextual dimensions; and (5) enhancing teachers' content knowledge for teaching. The potential of the Internet can be examined in the light of these five features as described below.

The Internet can be a tool for on-going learning because it enables teachers to find information anywhere, at any time. They do not have to wait for a workshop to get and share ideas with other teachers or educators (e.g., Newell et al. 2002). The Internet is also a potential tool for collaboration, allowing teachers to build networks, to share ideas about the subject matter, students' learning, and teaching (e.g., Butler et al. 2004; Hlapanis and Dimitracopoulou 2007).

The Internet provides different learning resources such as virtual manipulatives, visualisation of mathematical concepts, a variety of representations of mathematical concepts, as well as mathematical games (e.g., Moyer et al. 2008; Olive et al. 2010; Reimer and Moyer 2005). These enable teachers to cater to different individual learning styles or abilities, hence professional development would be student-oriented in nature.

The accessibility of the Internet at school or in the classroom allows teachers to learn many aspects of teaching in their own context (teachers' environment where the Internet is readily accessible) without leaving their schools (Dede 2006; Mushayikwa and Lubben 2009). Here, teachers must be treated as active learners who construct their own understanding as they are adults. Furthermore, the Internet could be a tool for teachers' learning, which implies that it has the potential to enhance teachers' content knowledge for teaching including subject matter, pedagogical, and curricular knowledge (Ball et al. 2008; Shulman 1986). This could be through learning mathematics, learning from other teachers' experiences, discussing specific teaching problems with experienced teachers via the Internet, reading related online books, or joining online conferences.

Since the purpose of this study was to seek a better understanding of the complex reality of mathematics teacher professional development, an approach was required that would enable an in-depth exploration of these interacting features with respect to information and communications technology (ICT) use. Such an opportunity is afforded through an ethnographic approach in which the researcher is directly immersed in the setting to investigate from inside the context, that is, in its natural setting (Eisenhart 1988; Emerson et al. 2001; Fetterman 1989; Freebody 2003).

In fact, the five characteristics of effective professional development (5cEPD) are well-matched with the nature of ethnography. Ongoing professional development can be achieved since ethnography requires the researcher to conduct the study for a significant period of time. Collaboration is an element of 5cEPD and also a principle of ethnography, which requires the researcher, who is living in the context, to develop a good professional relationship with the participants and attempt to gain the trust of the teachers and students. A student-oriented approach can be applied since the researcher spends a great deal of time as a participant observer and gets to know students' characteristics and their learning

needs. Additionally, considering the individual and the context of the teacher is possible because the ethnographer is inside the context. Lastly, enhancing content knowledge for teaching should be the aim of any teacher professional development, and this requires a better understanding of the teacher's knowledge and beliefs related to teaching and learning. Observation and ongoing analysis of classroom practices for a period of time enables the researcher to verify this and to gain internal access to the context as well as simultaneously to apply the 5cEPD. In addition to this, zone theory, developed by Goos (2005a), was used as an analytical tool to understand the factors that had supported and inhibited the effectiveness of the professional development model that was applied in this study.

Three zones of influence in teacher professional learning

The zone theory refers to three zones of influence in teacher professional learning (Goos 2005a). This theoretical model adopts Valsiner's zone theory, an expansion of Vygotsky's zone of proximal development (ZPD). The ZPD symbolises a space where an individual's potential for learning will occur. It is the distance between what a person can do with and without help. In Valsiner's studies of child development, he introduces two additional zones, the zone of free movement (ZFM) and the zone of promoted action. The ZFM represents what actions the child is allowed, while the ZPA represents actions that the adult promotes as an attempt to influence the child's behaviour (Valsiner 1997).

Goos extended the use of Valsiner's zone theory for several purposes: to understand the complexities of teachers' construction of identity (Goos 2005b), to study interaction between students, technology, and the teaching-learning environment (Goos 2006), to analyse the pre-service and initial professional experiences of a novice teacher in integrating technologies into his classroom (Goos 2005a), and to evaluate the effectiveness of the professional development (Goos et al. 2007a). Goos et al. (2007b) proposed the zone theoretical model of teacher learning and development as follows

> … [ZPD] represents teacher knowledge and beliefs, and represents the potential for development. This zone includes teachers' disciplinary knowledge, pedagogical content knowledge …, and beliefs about their discipline and how it is best taught and learned. … [ZFM] represents the professional context, which defines the teaching actions allowed. Elements of the context may include curriculum and assessment requirements, access to resources, organisational structures and cultures, and teacher perceptions of student background, ability and motivation. … [ZPA] represents the sources of assistance available to teachers in promoting specific teaching actions, such as that offered by a pre-service teacher education course, supervised practicum experience, professional colleagues and mentors in the school, or formal professional development activities. (pp. 416–417).

Goos (2006) argues that the relationship of the three zones provides a useful way of analysing the extent to which teachers adopt innovative practices involving technology. She theorises that the development of teachers is determined by the relationship between all the elements of the three zones. Therefore, this zone theory is appropriate as an analytical tool to understand the process of professional development in relation to the model used in this study.

The study

As stated by Allan (1991), "ethnography especially does not have the tidy, relatively linear progression of discrete stages common in experimental or questionnaire survey design" (p. 180). As such, detailed planning cannot be absolutely determined before conducting the research. However, ethnography requires a systematic way of collecting data and testing ideas (Allan 1991; Hammersley and Atkinson 2007). In this study, data were gathered through multiple methods, namely questionnaires, interviews (formal and informal), field notes, and written and non-written sources.

Three questionnaires were developed. The first questionnaire related to background information, such as the number of years of teaching, teaching qualifications, and professional development sessions. The second related to the use of Internet as a source of information, as a means of communication, and as a site for collaboration. The last questionnaire related specifically to the use of Internet for and in teaching mathematics. The questionnaires were supplemented by a face-to-face interview, with questions relating specifically to the items on the questionnaires. This interview was semi-structured and was used at the beginning of the study to seek clarification of teachers' responses to the questionnaires. Unstructured interviews were implemented at strategic points throughout the study, and included questions for clarification of what I had observed or experienced in the process of the ethnographic intervention.

I made field notes immediately after the observation. These were supported by several video-recorded mathematics lessons. Informal discussions with teachers during and after classes were also documented. Other data sources were printed and written, including the mathematics syllabus, notes about mathematical websites, and e-mail documents of professional communication. Non-written sources included lists of Internet "favourites" on the classroom computer and tracking of teachers' steps in using the Internet via the "history" in the websites.

For data analysis, I referred to what Hammersley and Atkinson (2007) stated:

> In ethnography, the analysis of data is not a distinct stage of the research. In many ways, it begins in the pre-fieldwork phase, in the formulation and clarification of research problems, and continues through to the process of writing reports, articles, and books. Formally, it starts to take shape in analytic notes and memoranda; informally, it is embodied in the ethnographer's ideas and hunches. (p.158)

Therefore, I continuously wrote my analytical notes and stories. I transcribed the interview data and the transcriptions were checked by native English speakers to ensure accuracy. Approximately every 2 weeks (for about 2 hours) I discussed my findings and my plans with two expert senior researchers in qualitative data analysis. These discussions were recorded. Through the process of these discussions, they challenged my ideas with other possible explanations of classroom events and assisted me in critically analysing the data. As a result my claims were developed in a rigorous and systematic fashion which facilitated refining my interpretations and emerging plans. Thus, the discussions with these experts became a significant part of my ongoing data analysis. In addition, I developed stronger explanations and deeper understandings of the teachers' Internet utilisation by continuously writing memos, creating tables/matrices and models/schemas, and constantly confirming and disconfirming evidence.

Herein lies both the potential strength and weakness of a study on professional development using ethnography. It is precisely the insider perspective of the ethnographer that enables a study of the significant issues in professional development, in all their interacting complexity. However, this is a labour-intensive process, and as such indicates the limitations of ethnography as a method for professional development per se (as distinct from a study of professional development).

Description of the ethnographic intervention

To illustrate the process of teacher professional development with respect to the use of the Internet, I used the case of a primary school teacher. Throughout this report, the teacher is given the pseudonym "Jack." This typical case is important for the field of mathematics education because it can illuminate issues for teachers who are familiar with technology in their daily life and have relatively high-speed Internet access in their environment including in their classrooms, but who are not yet integrating it into their own learning and teaching. It also illustrates the case of teachers who have a limited view of the potential of the Internet for professional development and are not yet familiar with online mathematical resources for themselves and for their students.

Jack's context

Jack was a beginning teacher who was in his second year of full-time teaching at the time of this study. In his first year, he taught Year 3 and was currently teaching Year 2. Jack has a Bachelor of Education (Primary) degree. During his first year of teaching, Jack attended several teacher professional programs but none of these related specifically to using the Internet for mathematics teaching and learning. Jack was a competent user of *Microsoft Word*, *PowerPoint*, *Excel*, and *Kid Pix*, and was familiar with *FrontPage* as a tool to create a website. Jack had access to the Internet both at school and at home and used it for e-mail, banking, and shopping. Jack told me that he became aware of the Internet for the first time "probably in Grade 8, about 1994."

Jack's classroom had a spacious feel. The desks for the 26 students were organised into five groups, leaving a large space for students to sit comfortably in a big circle on the carpet. The classroom had four computers and all were connected to the Internet. The classroom was also equipped with a printer, a data projector, and a video player as well as many manipulatives. Student work samples, art, and other notices hung on the wall. The school computer lab with nine Internet-connected computers and a fixed data projector were also available and had to be booked a week in advance. The school also provided ICT support. At any time, teachers could ring the ICT staff or request IT help online. The school and Jack's classroom appeared to be well resourced, especially in terms of ICT.

Researcher's role

I had two main roles in this study: namely, (1) as a participant observer and (2) a professional developer. Consequently, it was important to ensure that I developed both a deep understanding of the participant's (Jack's) engagement and immersed myself in professional

development activities pertinent to the investigation (including ICT workshops). Prior to working with Jack and to establish context, I spent time in a classroom with an expert teacher (Ann, named anonymously). These contextual observations included the classroom teacher's use of the Internet in her daily practices. Specifically, I focused on how she utilised the Internet for her own learning and how this learning impacted upon her mathematics teaching. In addition, I noted how she organised the classroom and facilitated her students' learning with the Internet; and how she used teaching resources from the Internet. The case of Ann has been described elsewhere (Patahuddin and Dole 2006). My professional development experiences with Ann influenced my preparation for working with Jack.

The classroom observations in Jack's class lasted 6 months, including two to four visits each week. In addition to classroom observations, I maintained regular online communication to determine the extent to which Jack might use the Internet whilst I was not present in the classroom. After a break of approximately 2 months I returned to Jack's classroom for a further 2 months. In total, I spent over 500 hours being a participant observer in Jack's classroom—indicative of the labour-intensive nature of ethnographic studies and approaches. Nevertheless, both the professional development and situated aspects of the engagement were essential in order to develop the desired level of depth in the analysis.

An interactive journey between Jack and the researcher

The process of this study was complex and neither linear nor fully pre-planned. It was shaped by the research on effective professional development programs using the Internet and the nature of an ethnographic approach. My aim was to assist Jack to reach the point where he would continue to develop his skills and expertise in exploiting the Internet over time for his professional learning and for use in professional work, and to explore the unfolding model of professional development.

This journey with Jack was characterised by five distinct phases. In Phase 1, I actively identified online resources and organised them into blogs, unobtrusively demonstrating a way of working with students in groups using the Internet, and showing directly several mathematical websites. This phase successfully captured Jack's interest in the use of the Internet for learning and teaching mathematics. In Phase 2, Jack started to search for websites, sharing websites with other Year 2 teachers, as well as presenting particular websites in his school staff meeting. However, Jack and I also faced some challenges in facilitating the use of the Internet by students for their learning. Phase 3 was characterised by feelings of uncertainty. Jack seemed to think I was there to help the students in the classroom, leaving me feeling that, while I expected Jack to engage with the Internet, he wanted me to do it for him. I made a time to talk with Jack so that I could clarify the direction of my work. An outcome of this interview was my locating websites to match Jack's teaching program. Phase 4 was characterised by this outcome. This was a task I did not want to continue to do. However, it received the most positive feedback from Jack about my time in his classroom. In the last phase (Phase 5), after leaving Jack's classroom for about 2 months I continued e-mailing websites, but Jack rarely replied to my e-mails. When I returned to his classroom, however, I found several significant changes in Jack's use of the Internet in his mathematics teaching.

In the following pages, I illuminate our journey and Jack's professional learning through selected critical incidents across the five phases. The selection was based on two main issues: first, how the researcher could start the intervention, and, second, how the

researcher should be critical in interacting with the way the teacher positioned the researcher. Since there is limited space to illuminate how the process worked in relation to the framework, I developed a set of codes C1, C2, C3, C4, C5, NE, or ZT. The codes, respectively, indicate that professional development needs to be ongoing[C1]; collaborative[C2]; student-oriented[C3]; situated in context[C4]; and enhancing content knowledge for teaching[C5]. The events reflect the nature of ethnography[NE] and the need of zone theory[ZT] for further analysis. For example, C2 indicates that the event(s) was (were) characterised or guided by the principle of collaboration or seen as an impact of collaborative nature. The codes are typed in superscript in order to maintain the flow of the ethnographic story and have been intentionally included to aid the readers in understanding how the framework was applied.

Issue 1: Start the action from where the teacher is

In the first 3 months of visiting Jack's classroom, I assisted Jack in any way required, including taking small groups of children for art activities, or working individually with children who required assistance with specific tasks. I also helped in distributing blocks or papers, assessing students' work, and typing things for Jack on the classroom computer. I often discussed the aims and the nature of my research with him. [NE]

After this period of time, particular incidents suggested that I was successful in gaining Jack's trust. For example, when I was playing with the students in the playground, Jack deliberately came to me and told me about his teaching program. He invited me to come and see how he assessed or interviewed students who might need some remediation as a part of the school program. He also allowed me to use his classroom computer. [NE]

In the second week of Term 2, my fieldnotes described Jack's teaching.

Jack was teaching about time. All the students sat on the carpet while Jack was sitting on the chair. He used a model of a clock that enabled him to move the hands of the clock and asked the question "What time is it?" It was 11 o'clock, 12 o'clock and so on. He posed similar questions. I heard some students comment: "It's easy peasy". It appeared to me that Jack wanted to make sure that all students knew that "…o'clock" means that the long hand points the 12 and the next hour would happen after the long hand turns around one time. [Field notes: 26/04/06]

In my reflection on this lesson, I realised that Jack's question did not provide an opportunity for students to think mathematically in extended ways about time. Particularly for students who already knew o'clock times, little challenge was being offered. Jack did not respond to the students who said "easy" several times to his questions. Realising that the Internet could cater for different needs of students, I searched for websites about time. One that I identified was called "Stop the clock." The picture on the screen showed five clocks set in analogue time and five boxes set in digital time. The instruction asked the user to drag the five digital times to the correct analogue times and then press "STOP THE CLOCK" to check the answer and to show how long the user took. [C3]

I found there were three levels of difficulty in this exercise. In Level 1, the times were set at either the hour or the half hour. In Level 2, the times were set at

either half-hour or quarter-hour intervals. In Level 3, the times were in five-minute intervals. I also found other games such as "Set the clock" in which the user has to click the arrow to demonstrate on a clock face the hour given in words; a matching game where the user has to match the time on the clock with digital time or words; and a game requiring deep concentration in which the user has to match the hidden times that appear when cards are flipped by clicking. [C3]

I organised the websites I had found into a blog that I had created for this study to enable me or Jack, or his students, to locate these websites easily.[C1, C2, C3,C5] My field notes described what occurred the next day.

> In the middle of a mathematics lesson, Jack walked around the class to check that every student was doing the assigned task. When I saw Jack close to the computer where I was sitting, I approached and told him that I had found websites for his students. He then asked me whether I wanted him to send students to work with me. I replied that I needed his help to firstly check whether these websites were appropriate[C4]. He checked the Clock website, namely Level 2, because he said that it probably matched with Grade 2 students. He found that this website contained the time in quarter hours which was not in his teaching program at the time. He said that it was quite difficult for his students. He then opened Level 1 and decided that Level 1 was appropriate. He then asked me to work with four students using the websites on two computers while he was continuing his lesson. [C2, C3] The four students worked in pairs. I facilitated them to do Level 1. The students worked out the problem and in just a few minutes most of these students could match the digital clock and the analogue clock. They said, "It's getting easy" and asked, "Can we go to the next level?" I let them click Level 2. With some discussion amongst the four students, they eventually solved the problems quickly. Several minutes after that, the students commented that Level 2 was getting easier. They agreed to go to Level 3. With a little help from me, they could do the tasks at this level. Eventually, the students asked permission to do the matching game. Some other students came to see this learning and asked for a chance to do the computer activity. They looked curious and interested and one commented on these websites by saying "Cooooooool." One of the students touched the mouse, indicating that he wanted to have a turn. While I facilitated the students with the website for about 20 min, Jack continued his teaching about addition strategies. [Field notes: 27/04/06] [NE, C2, C3, C4]

During this web-based activity, the students were enthusiastic. They engaged in discussion and worked out the problems in pairs. They seemed to be challenged by the different levels and variety of the websites. I could see students were capable of tasks of a higher level than Jack indicated when he checked the websites. [NE, C3]

At break time, Jack came to me to check on the students' learning. I reported his students' enthusiasm and told him that they worked Level 1 to Level 3 because all commented that every level was getting easier. I recorded Jack's reaction in my field notes.

> Jack then checked the websites again. He saw the websites and commented "It looks interesting." Jack then asked me the URL of these websites because he wanted to make a link from these to his classroom website. Jack also decided to make links from my blog to his classroom website, namely "Grade 2—web

games." He did this during the break time and it took him less than 2 min. (By clicking this, the user can access my blog which contains mathematical websites for children as well useful links for teachers.) Then Jack showed me his yearly mathematics plan. I thanked him for this, saying that it would help me in my search for suitable Internet resources that he could use in his learning and mathematics teaching. [Field notes: 27/04/06] [NE, C2, C3, C4]

Jack's actions demonstrated how easily he could, if he wished, enable students to access these websites from their home. Jack's action gave me hope that he could make more web links available for himself and his students as this took so little time for him to do. I even thought that Jack could possibly run a teacher professional workshop to share his ideas with other teachers in his school. I offered this idea to Jack in another informal conversation a week after the event described above, and he responded positively to my idea.[C2, C3, C4, C5]

At the end of this classroom visit, I reflected on the direction of my work with Jack. It seemed that I had made a kind of natural transition from being a helper for small groups of students to the promoter of the use of the Internet for Jack via helping students access them. I felt a sense of achievement. It occurred to me that this was an effective way of working because I modelled to Jack one way to incorporate the use of the Internet. Jack did not have to change his practice and he could watch me, and watch how his students responded to the Internet activities. Jack could see how his students enjoyed the mathematics learning with the Internet. It appeared that my working with Jack's students had captured his interest in online mathematics resources. I hoped that this would lead him to experience the Internet as a tool for his professional development (using it for his mathematics learning and in his mathematics teaching), and this was the main aim of my study.

In fact, several weeks after Jack's lesson on time, I observed him teaching another lesson on time using the Internet with a data projector. This was the first time I had observed him using the Internet in his mathematics teaching. Even though this teaching did not necessarily engage his students into thinking more mathematically [ZT], it suggested his desire to integrate the Internet into his teaching. In another week, Jack told me that he presented several mathematics websites to other teachers in his school staff meeting. Furthermore, I found that he sometimes shared the websites with other Grade 2 teachers using his classroom computers in the early morning before the class began. [NE, C1, C2, C3, C4, C5]

Issue 2: Be critical in interacting with the teacher

While I continued searching for websites for Jack and telling him about the resources that I had found, I started to feel uncertain about my work with him. I found that I was very busy searching for websites and I was questioning the direction of my research. I started to feel that Jack and I were going in different directions. I had hoped that he would engage more in learning to use the Internet, but it seemed that he expected me to do the work for him. [NE]

I again reflected on my aims of spending a great deal of time in Jack's classroom (it was already about six months) as well as examining what I had already done to support him. I found that I often waited for his responses to what I had done. I asked him

several times for comments through e-mails or face to face, and he rarely responded. When he did so, his comments were brief, for example, "good," "interesting," "great," and "thank you." I often puzzled over what he thought of my approaches and this was the main reason I decided to ask for an interview with him. This was part of my newly formulated plan to have regular meetings with him, as I always felt there was never enough time to talk with him during the school day. As a result, we scheduled a meeting time for an interview. [NE]

I wanted this interview to be different from our daily informal conversations. I told Jack I wanted to talk to him about things that I had done for him and to clarify some of my perceptions about his responses. I also hoped that through this interview we could come to an agreement about where to go next. [NE, C2]

The interview took place in his classroom after school. It lasted for about 30 min. I began the interview by telling him that I was trying to assist him to address what he saw as his problem (related to his comment made in the questionnaire) that using the Internet was "time consuming." I told him of the steps I had taken to provide him with websites for professional learning and mathematics teaching resources. I asked him how he would like me to support him. [NE, C2]

Jack proposed that I could help him to link his teaching program with websites or to organise the websites into strands (Numeracy, Pattern and Algebra, Measurement, Chance and Data, and Space). The following quotation gives the details:

> I think it would be handy, if you find the websites, put them into the different strands for Year 2. So, like almost in one [place] in maths overview, that you've got [what] we are doing. So what would save time, would be to have any resources, you know, lay it in line with a maths overview that I've given you, in the different strands.

To find out more about Jack's beliefs about teaching, I asked about his ideas on teaching using the Internet. He said that he would use it as I saw him using it, that is, teaching with a data projector. I then asked for his reasons for doing so and he explained:

> … because I find it is easy with a data projector because you can do it for a whole class at once. And I think, they can all sit down, they can all see it rather than have them to use the computers. And then I think I prefer to do it that way then have the children back to their desks and doing an individual activity from there, like maths textbook or something from the board, as a consolidation because we only have four computers and I don't have time to supervise them all. [ZT]

Jack added that

> Perhaps it's hard for kids to have them come back to work [when they are using computers] with what we ask the class to join in. Rather than use the technology for the whole class, they can go back to their desks and do that. [ZT]

Jack's words seemed to suggest that he preferred to interact with students this way because it is more directive, or easier to organise. He wanted to direct the class and this was more efficient for him. This confirmed my observation that by having all students together through the whole teaching activity, Jack found it easier to direct students to what he wanted them to do.

While Jack had known of the Beenleigh website (a website for online teaching resources which were already categorised into the syllabus strands) and had been appreciative of my efforts in showing it to him, he still expected me to complete his table linking his mathematics teaching plan with websites:

> You've got the mathematics overview. So you know what I am basically doing week by week. You can find Internet sites for topics we are doing in class or you can find sites that are suitable for more able children to work on or sites that are suitable for children who are struggling, and can work on themes on the day when you come up or you can find Internet sites where I can use the data projector for the whole class, so other ways that you can help. [NE]

Jack then opened his teaching program file for Term 3. He explicitly explained what he meant. His teaching program was organised in a table with two major columns (list of mathematics topics according to the five strands of the syllabus and the week in which the topic is planned to be taught).

His idea was to put appropriate websites in the third column. It occurred to me that he wanted me to give him ready-made material for each topic. My impression was that Jack had viewed me as a helper. We then agreed that Jack and I would have regular, short meetings once a week for 15 min and he promised to check the websites that I would identify for his teaching. [C1, C2, C3, C4, C5]

In one short meeting, Jack thanked me again for the great job I had done on the websites table and told me he had put this on the school website. He also told me that his school ICT coordinator really appreciated my work. Further, having many online resources made Jack interested in investigating ways to use them. In another short meeting, Jack asked me if I had ideas on "how to use all the great websites in routine classroom activities"[C2, C3, C4, C5]. He agreed to integrate the Internet in free-time classroom activities but he found it difficult to support his students as reflected in his words below.

> I've got four Internet programs, but some kids get to the end of the program and don't know what to do, or they have a problem, and then I have to stop what I am doing. Sometimes I am collecting notes and talking with kids and also trying to get my head around what I am trying to do for the day. I am getting my worksheets organised, or finding the roll, or doing a million other things that need to be done. So, you know, having the computers there, having the games up for the kids to use, it's good but I don't have the time to really come over to them. [ZT]

At this point in the year, about 3 weeks before the Term 3 holiday, I decided to stay away (as per my research design), although I was not sure whether I had had much impact. I told Jack that, even though I would not be able to come to his classroom, I would be available via e-mail.

I went back to Jack's classroom in the middle of Term 4. It was easy to continue my role as a participant observer as I was familiar with Jack's students and his classroom. I aimed to explore some changes in him in relation to the use of the Internet for learning and teaching mathematics.

My observation and informal conversations with students and Jack indicated increasing use of the Internet by Jack in his classroom. The students informed me that he had used the Internet in mathematics teaching several times. I found that many

websites I had listed on his work program had been placed in the favourites section of the computer. He had also reinstated rotational activities for mathematics, with one group working at the computers with parent help. This was a significant change, since he had told me of his preference for teaching using a whole-class approach instead of rotational activities. Also, he now permitted students to use the computers during free activities before school. This was another major change since I knew that before I left the school, the routine free activities in the morning did not include computer activity and I had found that Jack had experienced difficulties in organising this. I was very pleased to see these changes. [C1, C3, C4, C5]

Jack recognised the value of the "linked table" where I connected websites to his mathematics teaching program. He said:

> I used that table a lot as a teaching resource, like when I was looking for some ideas or something for the lessons and looking to show the kids something to the whole class, I found that table useful for this reason. I probably used that table once a week when I was doing my planning or looking for some ideas on the Internet. It's a good planning tool. [C3, C4, C5]

Jack's words confirmed my previous observation that since I had provided the table, he spent more time in exploring the websites that I had identified for him. During my time away from his classroom, he also used this table. Many of the websites listed in his Favourites were included in the linked table [C1]. However, Jack did not nominate "the linked table" as the best strategy to support a teacher, indicating his realisation of the enormous time investment required on an individual basis. Interestingly, it was this table that appeared to be a strong catalyst for his exploration of listed Internet sites. The most significant finding from this critical incident is that he actually used the Internet when I was away, even though he did not inform me about this [C1].

Analysing the ethnographic intervention

The 5cEPD framework

In relation to my work with Jack, there was evidence to show he continued his learning using the Internet, indicating success in the on-going aspect of the model. During my absence from his classroom, for example, Jack had explored websites I had identified for him (as he transferred them to the "Favourites" section of his computer). Moreover, 3 months after the end of my time working with him, during which time Jack had relocated overseas to another school, he emailed me, stating: "I was just on your blog looking at some of your great resources." This comment indicates that, after a significant period of time, he was still accessing the resources that I had compiled for him. These two positive signs are not sufficient to indicate clearly the longer-term impacts of Jack's ongoing professional development strategies, but they provide evidence of his growing awareness of the professional development potential of the Internet.

In designing the professional development program for Jack, I significantly considered and promoted collaboration aspects as indicated by C2 in the story. Jack appeared to work collaboratively, both with me and his colleagues, but rarely in the virtual world. He used the Internet simply as a means for local collaboration, such as

for sharing mathematical websites with other Grade 2 teachers and presenting information about websites in a staff meeting at his school.

My efforts in relation to Jack were also designed to assist him to use the Internet to find professional resources compatible with both his instructional goals in mathematics and his students' needs. Hence this professional development was student-oriented in nature. My work with students enabled me to identify different online learning resources that matched their needs, as indicated by C3. As a result, Jack's interest in online mathematical resources was captured, as he could see his students' enthusiasm in learning mathematics when using the Internet.

As suggested in the literature, professional development should take into consideration the classroom/school context of the teacher, and also treat teachers as active learners who construct their own understanding. I made a conscious effort to treat Jack as an adult learner and a professional throughout this study, especially by valuing his constructive ideas, as indicated by C4. I often asked for Jack's ideas/judgement on websites before offering them to students and he suggested several websites that I should offer to his groups of students. In terms of context, I took note of the fact that, though Jack's classroom had four computers with a good Internet connection, they were rarely used by students for learning. I often took the opportunity to propose the use of the Internet to enrich his students' mathematics learning. Also, knowing that Jack's school encouraged professional sharing among teachers, I suggested that he should share information about websites relevant to his mathematics teaching with other teachers in the same year levels, and he responded positively. The key feature C4 is in fact an in-built strength of ethnography.

In my work with Jack, I attempted to promote pedagogy for student learning of mathematical content, indicated by C5. For example, when I noticed he provided few activities that catered for the various interests and abilities of his students, I offered many different online resources for particular mathematical topics that he was teaching at the time. I also offered websites that contained some teaching ideas that had been developed by professional organisations. I was hoping that a continued use of the Internet in the future for greater individual professional development would help him in developing his content knowledge of mathematics teaching.

The coding related to the first issue shows that the strategy of starting the intervention from where the teacher was actually engaged, was critical. This is for sustaining ongoing learning and collaboration, obtaining a student learning focus, being sensitive to the teacher's context, and hoping that he could develop his knowledge as a professional. Quite differently, with regard to the second issue, the example shows that the success in establishing a collaborative relationship with Jack did not mean that I had control in directing the professional development. However, I found that the initiative that came from Jack had a great effect on his use of the Internet. Also, a number of noticeable factors that supported his attempts to use the Internet for his learning and teaching, and a number of factors that interfered with change, can be better understood through analysis based on zone theory.

Three zones of influential factors to professional learning

As indicated earlier, Goos proposed that the ZPD represents teacher knowledge and beliefs. The elements of Jack's ZPD include his knowledge and his beliefs about mathematics, mathematics teaching and learning, and the roles of the Internet for

mathematics learning. There were occasions where Jack's ZPD seemed limited. For example, in my working with him, he preferred a "teacher-centred approach." This was clearly indicated by his rationale for using the data projector instead of giving students opportunities for more individualised instruction (as indicated in the first and second critical issues). My observations suggest that Jack's practice in challenging his students' mathematical thinking and problem solving was not aligned to the curriculum document mandated in the education jurisdiction. He also appeared to see the Internet as an "add-on." This seems to have been based on his beliefs that the Internet is just another tool and teachers do not necessarily have to use it. I also discovered his difficulties in managing the students' learning using the Internet.

The zone of free movement (ZFM) represents "constraints and affordances within the professional context" (Goos et al. 2007a, p. 26). Thus, Jack's ZFM is shaped by the inhibitors and the affordances in his context. Many elements of Jack's ZFM were positive. For example, the school was well-resourced. The children were mostly from wealthy and well-educated families representing many cultures, and they were motivated and well-behaved. His classroom had access to four computers with a fast Internet connection and with the support of ICT staff. These presented favourable opportunities to use the Internet for mathematics teaching and learning. However, Jack had limited perceptions of other elements of his ZFM. The story presented indicates Jack's perception of his students' abilities (ZFM) was quite low; for example, he tended to pose simple problems for his students. Time also seemed a problem for him. He gave up providing opportunities for students to access the Internet in their free time in the morning as it was the busiest time of day for him in managing his teaching plan. He worried about lack of time for teaching if students were involved in many group activities.

Although Jack's professional context (ZFM) was favourable in affording Internet use, his limited ZPD (knowledge and beliefs) seemed to restrict him from taking advantage of his technology-rich context. Thus, my role was to align his ZPD more closely with his ZFM. In this case, the researcher's efforts were one element in Jack's ZPA. The "linked table" strategy yielded positive outcomes in that it gave Jack more time to explore mathematical websites. He also began to ask: "How can we use all these great websites without using rotational activities?" This suggested that he had started to realise that his existing preferences and beliefs about teaching with data projector presentations were not compatible with his new notions about teaching with the Internet.

In analysing this event using zone theory, the ZPA aspect I offered seemed successful in challenging Jack's ZPD. This aligns with the explanation: "… efforts to help teachers make significant changes in their teaching practices must also help them to acquire new knowledge and beliefs. At the same time, teachers come to understand new practices through their existing knowledge and beliefs" (Borko et al. 1997, p. 272).

Reflections and implications

The focus of this paper is to reflect on the developed model that was informed by (1) a working model of professional development from analysis of the field, (2) zone

theory of teacher professional learning, and (3) ethnography as a method. This reflection is through a typical case with two critical issues: First, there is a need to start the action from where the teacher is, and, second, there is a need to be critical in interacting with the teacher. What, then, can we learn from this model in relation to its power, challenges, promise, and feasibility both for the teacher and professional developer?

In general, this study shows complex personal and contextual phenomena in interaction with teacher learning. The model proved to be powerful within this complexity, such as enabling me to understand Jack's current use of the Internet and helping me in interacting with this and in designing the intervention. As a result, I successfully created conditions to empower Jack, such as stimulating his engagement in exploiting the Internet for learning. Without my directions, he confidently promoted several websites to other teachers. Without my presence in his classroom, he accessed the websites and increasingly used them for his students' mathematics learning. His willingness to use the Internet increased significantly after experiencing the compatibility of the selected mathematical websites with his mathematics teaching program.

However, the model also proved to be challenging for the teacher and for me, as a researcher. This required me to be a critical ethnographer. My working relationship led to unintended consequences. Jack seemed to position me as not just a researcher but also a helper. For example, he asked me to work with his students and find mathematical websites for his teaching program. Similarly, Jack himself faced challenges. It was not easy for him to accept fully this technology and his responses were mixed. He attempted to use the Internet in his teaching, but this was through whole-class instruction and using the data projector. He wanted to allow students to work independently at the computers in their free time, but found they needed continual assistance, which he found difficult to provide due to time constraints.

The story shows an uneven but progressive learning process for the teacher and for me as a professional developer. My efforts in promoting the Internet (ZPA) created a better alignment between Jack's ZPD and ZFM, and this intersection held promises for the development of the teacher. This may indicate that working with teachers who have larger compatibility between ZPD and ZFM would promise a more productive impact. Also, this study illustrates my professional development as a teacher educator. Experiencing the challenges which the study presented enabled me to develop new personal and professional skills. Researching the educational potential of the Internet meant that I learned how to use it more effectively, and this has enabled me to promote the potential of the Internet to a broader community in this increasingly digitalised world.

Prior to this study, I held a strong assumption that there was a need to work with teachers in the classroom. This was based on my personal experiences as a professional developer in mathematics education and my examination of the limitations existing in professional development, which often fails to match the local needs of teachers' classroom situations (Borko 2004; Little 1993; Putnam and Borko 1997; Wilson and Berne 1999). I had argued that there was a need for supporting teachers in their own classrooms because many ICT professional development programs fail to explain how teachers apply in their classrooms what they learn in professional development programs (e.g., Gibson and Oberg 2004; Gibson and Skaalid 2004). Studies based on programs which take teachers outside of their classrooms often fail to

address the issue of compatibility with the actual characteristics of the students and their learning environment. Therefore, throughout this study I was enthusiastic and passionate about working with Jack in unfamiliar contexts and functioned as an ethnographer. However, reflection on this experience has challenged my assumptions, since offering new ideas to Jack in his classroom seemed to compete with other classroom priorities. What does this mean for professional development to take into account constraints, such as dealing with complexity of practice and low take up of online resources? Perhaps one perfect model for all needs and all circumstances does not exist.

Due to this complexity, one might ask a challenging question: How effective and efficient is this teacher professional development model? The labour intensity of such an investigation is such that there are limits to ethnography as a method for professional development per se. What is also explicit and visible is the role of the researcher, in this case the teacher educator as an ethnographer. This role is often obscured in studies of professional development that do not draw on ethnography. However, the feasibility of this model needs further study. How such an approach would work with a larger group of teachers is yet to be determined. With the individualised nature of the professional development used in this study, translation to a larger group poses questions about efficiency and effectiveness. What ethnography highlights is a personal and situational interplay, not only for the teacher, but also for the researcher, and the interplay between these roles. Furthermore, by applying this integrated theory (ethnography, 5cEPD, and zone theory), we gain deeper and comprehensive understandings of the complexity of professional development in and through Internet use.

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